Barcelona Supercomputing Center
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The Atmospheric Iron Cycle in EC-Earth

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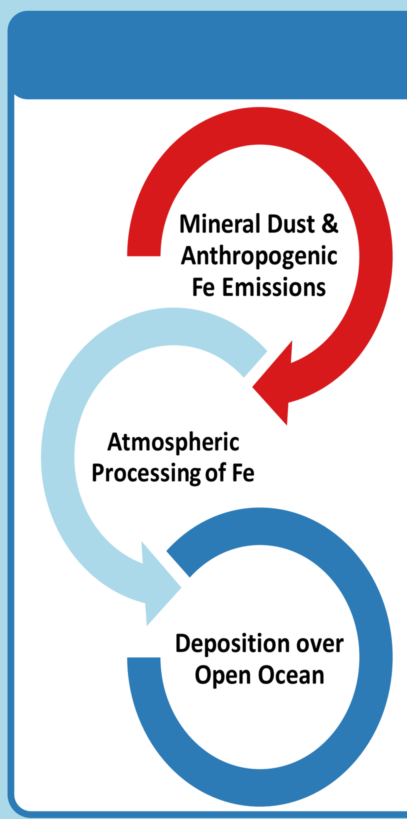
Background & Aim



Ocean productivity relies upon bioavailable iron (Fe) for photosynthesis, respiration and nitrogen fixation, which makes the Fe biogeochemical cycle a key modulator of the ocean's ability to uptake atmospheric CO_2.

The **main external input of Fe** to the open ocean surface is atmospheric deposition, which derive mainly from:

- **Soil dust aerosol** transported from arid and semi-arid regions (~95%).
- **Combustion sources** of Fe (~5%).

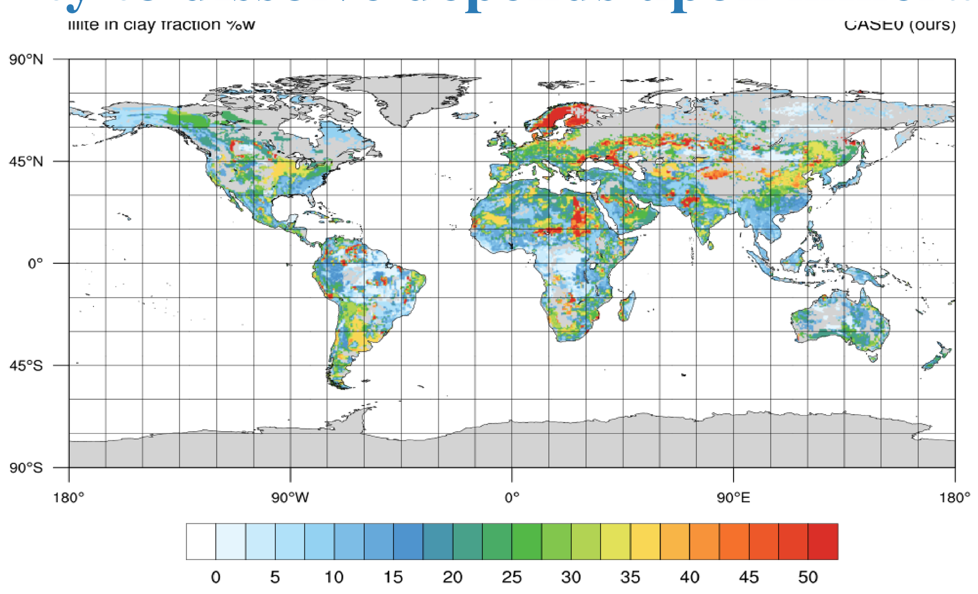
Fe in freshly emitted soil dust is mostly **insoluble**, but it is hypothesized to be partly transformed **into bioavailable Fe** species during atmospheric transport through a variety of **dissolution mechanisms**.

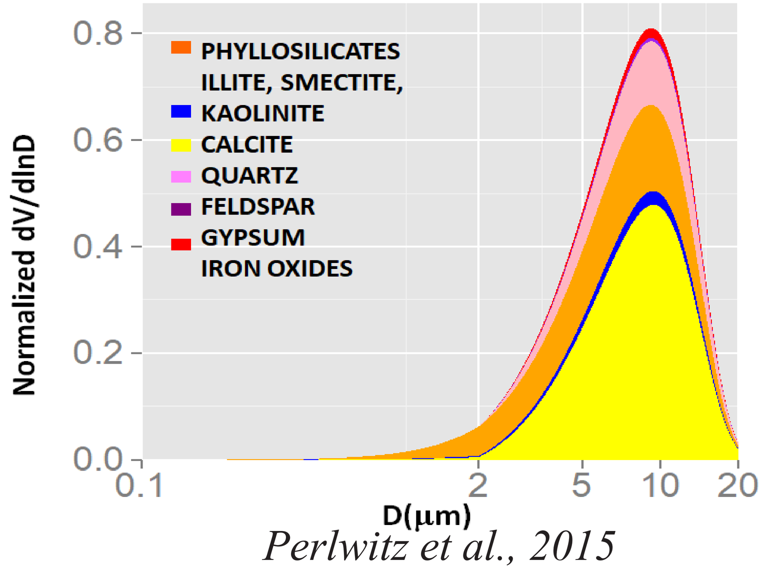
This work aims to develop and constrain the atmospheric Fe cycle in EC-Earth to improve our understanding of the atmospheric delivery of bioavailable Fe to the ocean.

Methods

Fe-Dust emissions

Mineralogy Rather than a homogeneous species, as many Earth System Models assume, dust is a heterogeneous mixture of different minerals. **The dust Fe content, speciation and ability to dissolve depends upon mineralogy.**





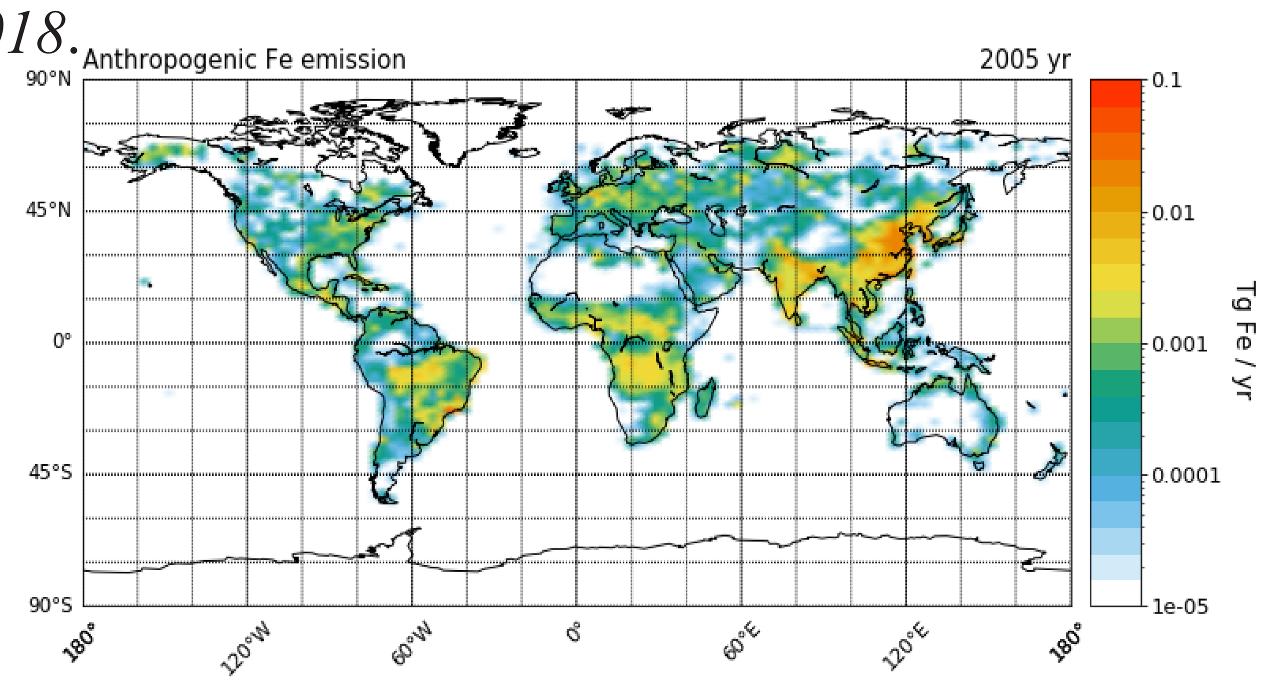
Perlwitz et al., 2015

Emitted Size Distribution We will improve and apply our extended version of brittle fragmentation theory *(Kok, 2011)* to represent the emitted PSD of each mineral in each grid cell of the model.

Fe-release The percentage content in Fe of the different Fe-containing minerals of dust that are considered in the model has been taken from Nickovic et al. (2013).

Fe-Anthropogenic emissions

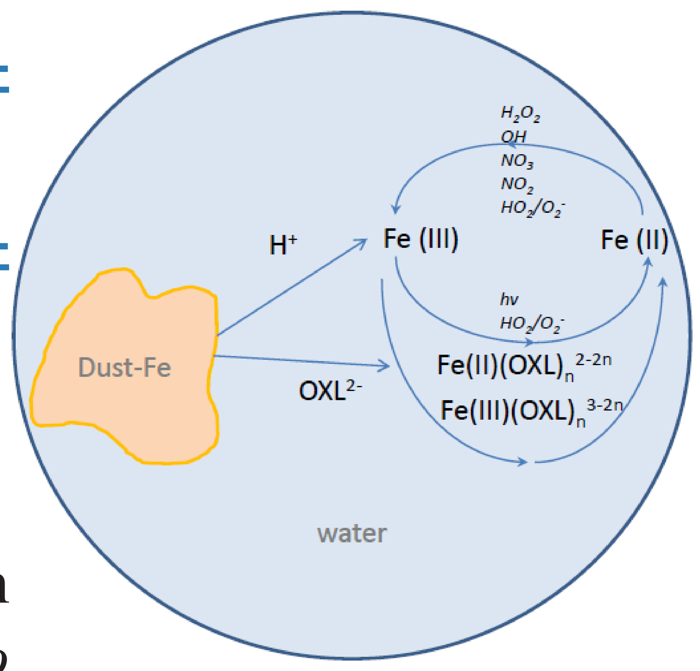
Scaling factors of total Fe emissions to those of BC **(Fe /BC)** and OC **(Fe/OC)** for each of the emission sectors in the IPCC-AR5 used inventory have been derived based on emission estimates provided by *Ito et al. 2018*.



Dissolution scheme

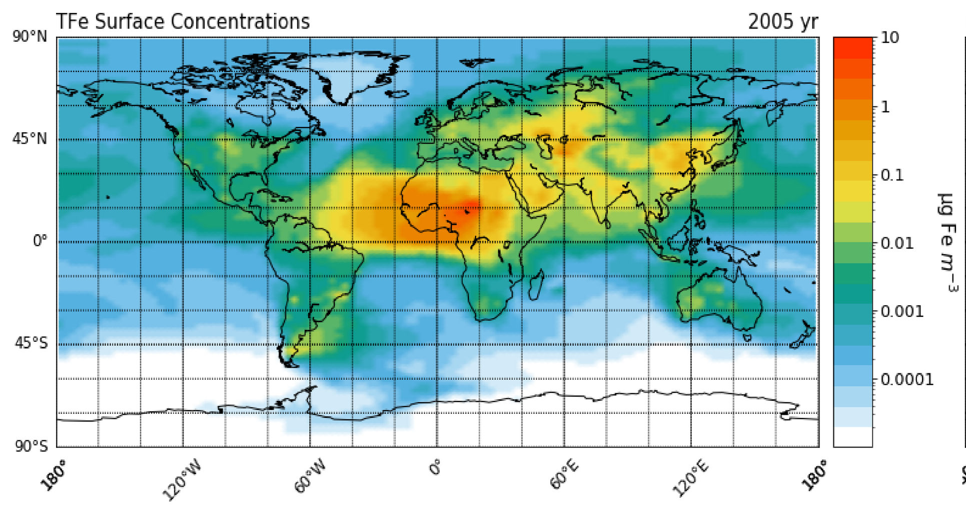
The model simulates aqueous-phase chemistry in aerosol water and cloud droplets as described in *Myriokefalitakis et al. (2011)*. The Fe dissolution from minerals is treated explicitly as a kinetic process:

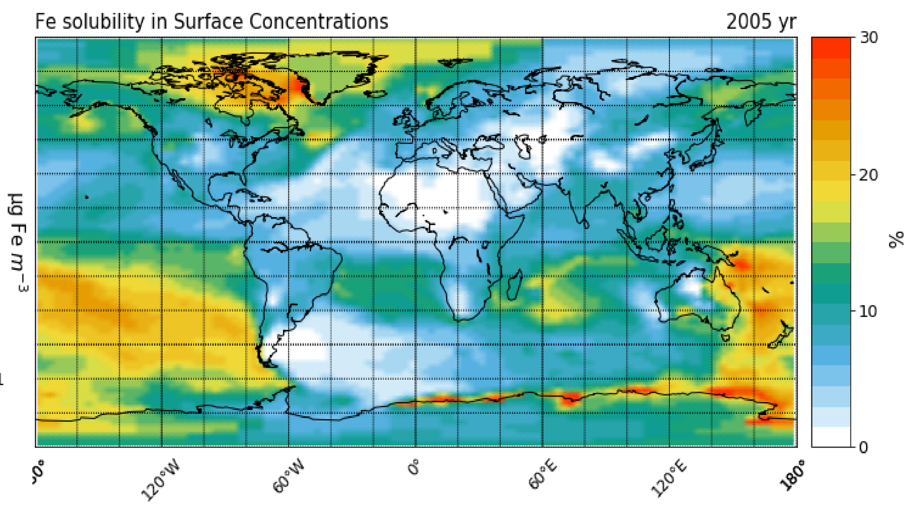
- (a) Proton-promoted Fe dissolution **[Atmospheric acidity]**
- (b) Oxalate-promoted Fe dissolution **[Organic ligands]**
- (c) Quasi-photo-reductive Fe dissolution.



Myriokefalitakis et al. (2015)

We plan to additionally include the Fe from combustion into the dissolution schemes *(Ito et al. 2015)*.



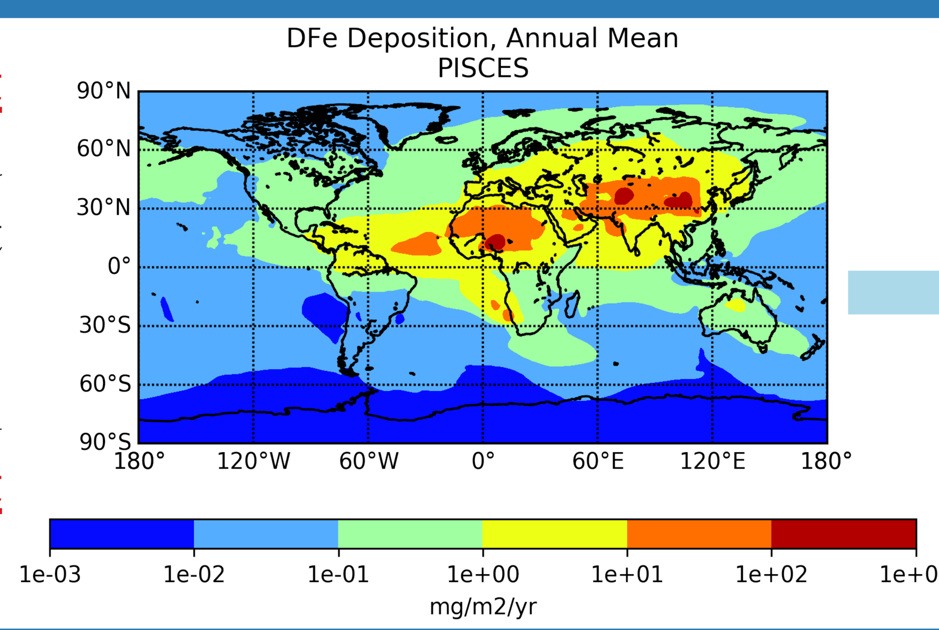


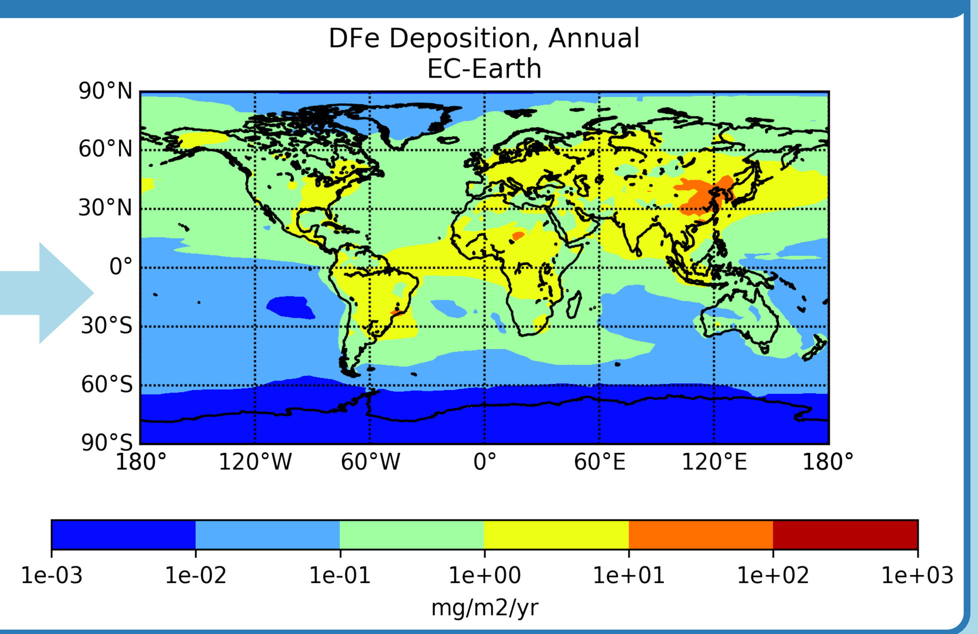
Planned Experiments & Evaluation

- **Time-slice experiments for the present-day and future climate scenarios** will be carried. We expect that projections will largely depend upon projected changes in anthropogenic emissions.
- **Present-day simulations will be evaluated** against available compilations of total Fe deposition and concentration measurements.

Expected work outcome

- **This study will allow to do fully coupled simulations that acount for the effect of bioavailable Fe variations** upon the carbon and nitrogen cycles (currently ESM base the determination of the amount of soluble Fe deposited over ocean on climatological information).
- The implementation of a explicit mineralogy for dust in EC-Earth will also allow a more detailed exploration of **other effects of dust on climate.**





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Ito et al. (2018) Scientific Reports, 8, 7347 ; **Kok (2011)** Proc. Natl. Acad. Sci. U. S. A., 108, 1016–21. ; **Myriokefalitakis et al. (2011)** Atmos. Chem. Phys., 11, 5761-5782 ; **Myriokefalitakis et al. (2015)** Biogeosciences, 12, 3973–3992 ; **Nickovic et al. (2012)** Atmos. Chem. Phys., 12, 845–855. ; **Perlwitz et al. (2015a)** Atmos. Chem. Phys., 15, 11593–11627.

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